

## XVI. Sayh al Uhaymir 005/094

Basalt, ~11 kg.

Apparent strewn field (about 9 pieces)



**Figure XVI-1.** Photograph of Sayh al Uhaymir 094 as it was found in Oman. Note the luster.

### **Introduction**

In November 1999, five macroscopically identical stones were recovered at two sites about 1800 meters apart in Oman, at a location called Sayh al Uhaymir. These were labeled **SaU 005** and **SaU 008** and have a combined weight of 9923 grams (Zipfel 2000). Additional pieces, labeled **SaU 051** and **SaU 094**, were recovered by a Swiss expedition in January 2001 (Hofmann *et al.* 2001; Grossman and Zipfel 2001; Gnos *et al.* 2002) weighing 436 grams and 223 grams respectively, and the strewn field has been extended to 2.5 by 1.5 km. Four additional fragments **SaU 060** (42 g), **SaU 090** (95 g), **SaU120** (75g) and **SaU150** (107g) were reported by Russell *et al.* (2002, 2003).

SaU basaltic shergottites are very similar in mineralogy, texture, chemistry and exposure age to the DaG shergottites from Libya, but terrestrial weathering (caliche) appears to be much less pronounced (Zipfel 2000; Dreibus *et al.* 2000).

Two sides of SaU 094 (Gnos *et al.* 2002) are coated with very thin black fusion crust. Russell *et al.* 2003 report that SaU 120 has a “well preserved black fusion crust”.

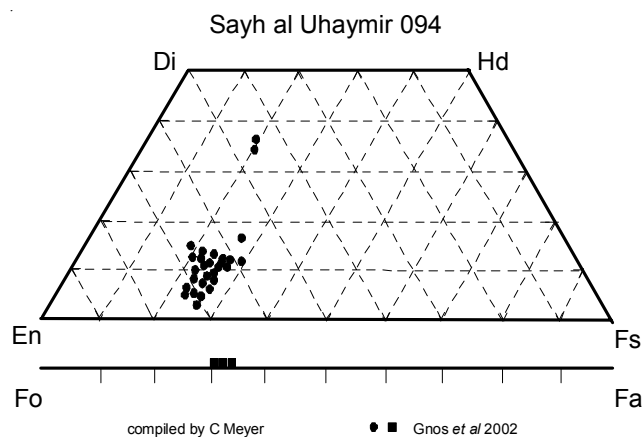
### **Petrography**

SaU 005 has a porphyritic texture of large olivine phenocrysts set in a fine-grained groundmass of low

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### **Mineralogical Mode**

	<b>Zipfel (2000)</b>	<b>Gnos <i>et al.</i> (2002)</b>	<b>Bartoschewitz (2003)</b>
Pyroxene	48 vol. %	52 - 58	56
Olivine	25	22 - 31	23
Maskelynite	15	8.6 - 13	17
Opaques		~ 1	1
Sulfide		0.1 – 0.2	
Phosphates		<<0.1	
Melt Pockets		4.8 – 6.7	~3



**Figure XVI-2:** Composition diagram for pyroxene and olivine from SaU 094 (data replotted from Gnos *et al.* 2002).

Ca pyroxene and maskelynite (Zipfel 2000). Olivines showing mosaicism and planar features, severely fractured pyroxenes and maskelynitized feldspar indicate that this meteorite was highly shocked. Veins and pockets of “vesicular shock melt” were found to be abundant (~9 %!), with vesicles up to 3 mm in size.

Goodrich and Zipfel (2001a, b) have studied the melt inclusions in chromite and olivine. The glass in these inclusions is high Si = 70-74%.

Gnos *et al.* (2002) have studied the shock melt patches in SaU 094 and conclude that the shock pressure was locally as high as 80 GPa. Minute oblate vesicles are common in the glassy and recrystallized shock melts and have a preferred orientation.

Caliche from SaU 008 has been studied by Schwenzer *et al.* (2002).

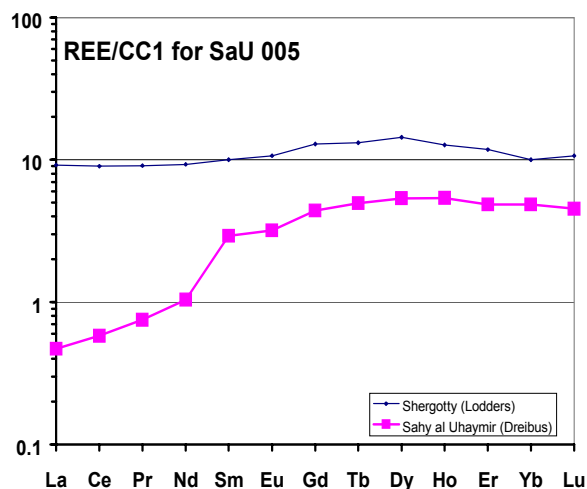
### Mineral Chemistry

**Olivine:** Large olivine phenocrysts (2 mm) are normal zoned from Fo<sub>71</sub> to Fo<sub>65</sub>. Olivines in groundmass are ~Fo<sub>65</sub>.

**Pyroxene:** Pigeonite is En<sub>70</sub>Wo<sub>6</sub> to En<sub>61</sub>Wo<sub>13</sub> and augite is En<sub>50</sub>Wo<sub>32</sub> (figure XVI-2). There is no orthopyroxene.

**Feldspar:** Maskelynite is An<sub>51-65</sub>Or<sub>0.3-0.9</sub> and relatively homogeneous.

**Oxides:** Gnos *et al.* (2002) have reported detailed analyses of chromite, ulvöspinel and ilmenite.



**Figure XVI-3:** Normalized rare earth element diagram for SaU 005 (Dreibus *et al.* 2000) compared with that of Shergotty (Lodders 1998).

**Phosphate:** Merrillite Ca<sub>9</sub>Na(Mg,Fe)(PO<sub>4</sub>)<sub>7</sub> contains considerable F and trace Cl.

**Sulfides:** Detailed analyses of sulfides are given in Gnos *et al.* (2002) who report a non-magnetic pyrrhotite Fe<sub>10</sub>S<sub>11</sub> and some pentlandite exsolution.

**Glass:** Boctor *et al.* (2001) have determined the chemical composition of the shock melt glass as MgO=23.8-34.6%, FeO=16.4-24.7%, CaO=2.1-10.6%, SiO<sub>2</sub>=46.6-51.6%, Al<sub>2</sub>O<sub>3</sub>=1.3-1.8% and have reported the D/H ratio. Gnos *et al.* (2002) have also analyzed shock glass in this rock.



**Figure XVI-4:** Photograph of SaU 094 kindly provided by Edwin Gnos.

**Table XVI-1: Composition of Sayh al Uhaymir.**

<i>reference weight</i>	Dreibus 2000 5.4 grams!		Dreibus 2000		Gnos 2002 fusion crust	
SiO <sub>2</sub> %	47.2	(a)			48.49	(e)
TiO <sub>2</sub>	0.42	(a)			0.41	(e)
Al <sub>2</sub> O <sub>3</sub>	4.53	(a)			4.97	(e)
FeO	18.34	(a)	17.8	(b)	16.34	(e)
MnO	0.46	(a)	0.45	(b)	0.43	(e)
CaO	5.74	(a)	5.18	(b)	5.62	(e)
MgO	20.49	(a)			20.54	(e)
Na <sub>2</sub> O			0.6	(b)	0.64	(e)
K <sub>2</sub> O			0.022	(b)		
P <sub>2</sub> O <sub>5</sub>	0.31	(a)				
<i>sum</i>						
Li ppm						
C %	0.11	(c )				
F			56	(b)		
S %	0.16	(c )			tr.	
Cl			143	(b)		
Sc			29.9	(b)		
V	136	(a)				
Cr					tr.	
Co			55	(b)		
Ni			310	(b)		
Cu						
Zn			61	(b)		
Ga			8.8	(b)		
Ge						
As			0.46	(b)		
Se						
Br			0.28	(b)		
Rb						
Sr						
Y						
Zr						
Nb						
I ppm			1.9	(b)		
Cs ppm						
Ba						
La	0.11	(d)	0.1	(b)		
Ce	0.35	(d)	<.6	(b)		
Pr	0.067	(d)				
Nd	0.47	(d)	<.65	(b)		
Sm	0.43	(d)	0.42	(b)		
Eu	0.18	(d)	0.2	(b)		
Gd	0.86	(d)				
Tb	0.18	(d)	0.19	(b)		
Dy	1.3	(d)	1.42	(b)		
Ho	0.3	(d)	0.3	(b)		
Er	0.77	(d)				
Tm						
Yb	0.79	(d)	0.81	(b)		
Lu	0.11	(d)	0.13	(b)		
Hf	0.43	(d)	0.39	(b)		
Ta						
Th ppm	0.012	(d)	<.1	(b)		
U ppm	0.05	(d)	0.05	(b)		

*technique (a) XRF, (b) INAA, (c ) CSA, (d) MIC-SSMS, (e) electron probe*

### **Whole-rock Composition**

Dreibus *et al.* (2000) report that the chemical composition of SaU 005 (Table XVI-1) is similar to that of DaG 476 (figure XVI-3). The Ga/Al ratio is  $4.4 \times 10^{-4}$ . Gnos *et al.* (2002) determined the composition of the fusion crust.

### **Cosmogenic Isotopes and Exposure Ages**

Pätsch *et al.* (2000) report an exposure age of  $1.5 \pm 0.3$  Ma from  $^{22}\text{Ne}/^{21}\text{Ne}$  measurements (similar to that of DaG476). Pätsch *et al.* also report a high  $^{26}\text{Al}$  (37.4 dpm/kg), but low compared to the calculated saturation value. Park *et al.* (2001) report a  $^{21}\text{Ne}$  exposure age of 0.7 Ma. Park *et al.* (2003) report additional exposure ages and K-Ar ages for SaU. Bastien *et al.* (2003) determined  $^{10}\text{Be}$  ( $13.5 \pm 0.4$  dpm/kg),  $^{26}\text{Al}$  ( $48.5 \pm 1.7$  dpm/kg) and  $^{53}\text{Mn}$  ( $78.6 \pm$  dpm/kg).

Park *et al.* (2003) calculate an ejection age of 0.81 Ma.

### **Other Isotopes**

Hoffmann *et al.* (2001) and Gnos *et al.* (2002) reported  $\Delta^{17}\text{O} = +0.28$  per mil (which is thought to be low because of terrestrial contamination). Grossman and Zipfel (2001) reported  $\delta^{17}\text{O}$  as +2.51 per mil and  $\delta^{18}\text{O} = +4.29$  per mil (as determined by Franchi). Bartoschewitz and Appel (2003) reported  $\delta^{17}\text{O}$  as +2.78 per mil and  $\delta^{18}\text{O} = +4.74$  per mil for SaU150.

Mohapatra and Ott (2000) and Mohapatra *et al.* (2001) have found that the high temperature fraction of the  $^{15}\text{N}$ ,  $^{129}\text{Xe}$  and Kr/Xe ratio in gas released from the “shock melt glass” are representative of the Martian atmosphere. Schwenzer *et al.* (2002) have studied the nitrogen and noble gases in caliche from SaU 008. Nishiizumi *et al.* (2001) report preliminary analyses of  $^{10}\text{Be}$ ,  $^{26}\text{Al}$ ,  $^{36}\text{Cl}$  and  $^{21}\text{Ne}$  and find similarity with Dar al Gani 476.

### **Terrestrial Weathering**

Calcite veinlets are common at the surface of the SaU 094 and patches of Fe hydroxide occur as fillings of cracks and as small pockets of finely layered oxidation products of mixed phases. However, pyrrhotite usually shows no sign of oxidation (but see detailed discussion in Gnos *et al.* (2002).

### **Extra-terrestrial Weathering**

Hoffmann *et al.* (2001) mentioned probable “shocked Fe-carbonate”, but this has not been confirmed.



*Figure XVI-5. Approximate location of meteorite recovery fields (see Meteorite Bulletin).*

### **Processing**

These samples are reportedly\* found on a Miocene fresh-water limestone gravel plateau about 43 km south of Al Ghabar, Oman.

X-ray tomograms of SaU 094 were made before slicing the sample – see Gnos *et al.* (2002).

\* Rainer and Sven Bartoschewitz (see Russell *et al.* (2003)).